LONDON-WEST MIDLANDS ENVIRONMENTAL STATEMENT

Volume 5 | Technical Appendices

CFA5 | Northolt Corridor

Flood risk assessment (WR-003-005)

Water resources

November 2013

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Department for Transport

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High Speed Two (HS2) Limited,
Eland House,
Bressenden Place,
London SW1E 5DU

Details of how to obtain further copies are available from HS2 Ltd.

Telephone: 020 7944 4908

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1 Introduction

1.1 Structure of the water resources and flood risk assessment appendices

1.1.1 The water resources and flood risk assessment appendices comprise three parts. The first of these is a route-wide appendix (Volume 5: Appendix WR-001-000).

1.1.2 Specific appendices for each community forum area (CFA) are also provided. For the Northolt Corridor area (CFA5) these are:

- a water resources assessment (Volume 5: Appendix WR-002-005); and
- a flood risk assessment (i.e. this appendix).

1.1.3 Maps referred to throughout the water resources and flood risk assessment appendices are contained in the Volume 5, Water Resources and Flood Risk Assessment Map Book.

1.2 Scope and structure of this assessment

1.2.1 This flood risk assessment (FRA) considers the assessment of flood risk in CFA5. The assessment has been carried out in accordance with the requirements of the National Planning Policy Framework (NPPF)[1] which aims to prevent inappropriate development in areas at risk of flooding and to ensure that, where development is necessary in areas at risk of flooding, it is safe without increasing flood risk elsewhere.

1.2.2 The FRA methodology and a review of the relevant local planning policy documents are provided in Section 2 of this report. The design criteria are provided in Section 3 and Section 4 documents the sources of information that have been reviewed. Section 5 provides a description of the planned works within CFA5. Section 6 considers baseline flood risk and the risk of flooding to the Proposed Scheme from all relevant sources. Flood risk mitigation measures included within the Proposed Scheme are detailed in Section 7. The effect of the Proposed Scheme on the risk of flooding is considered in Section 8.

1.3 Location

1.3.1 CFA5 covers an 8.7km section of the route. It is bounded by the Park Royal Road Bridge in the east and extends to the western boundary of the London Borough of Ealing (LBE) as shown in Figure 1. The Proposed Scheme within CFA5 incorporates the twin bore tunnels between the Kilburn (Brent) to Old Oak Common area (CFA4) in the east and the South Ruislip to Ickenham area (CFA6) in the west.

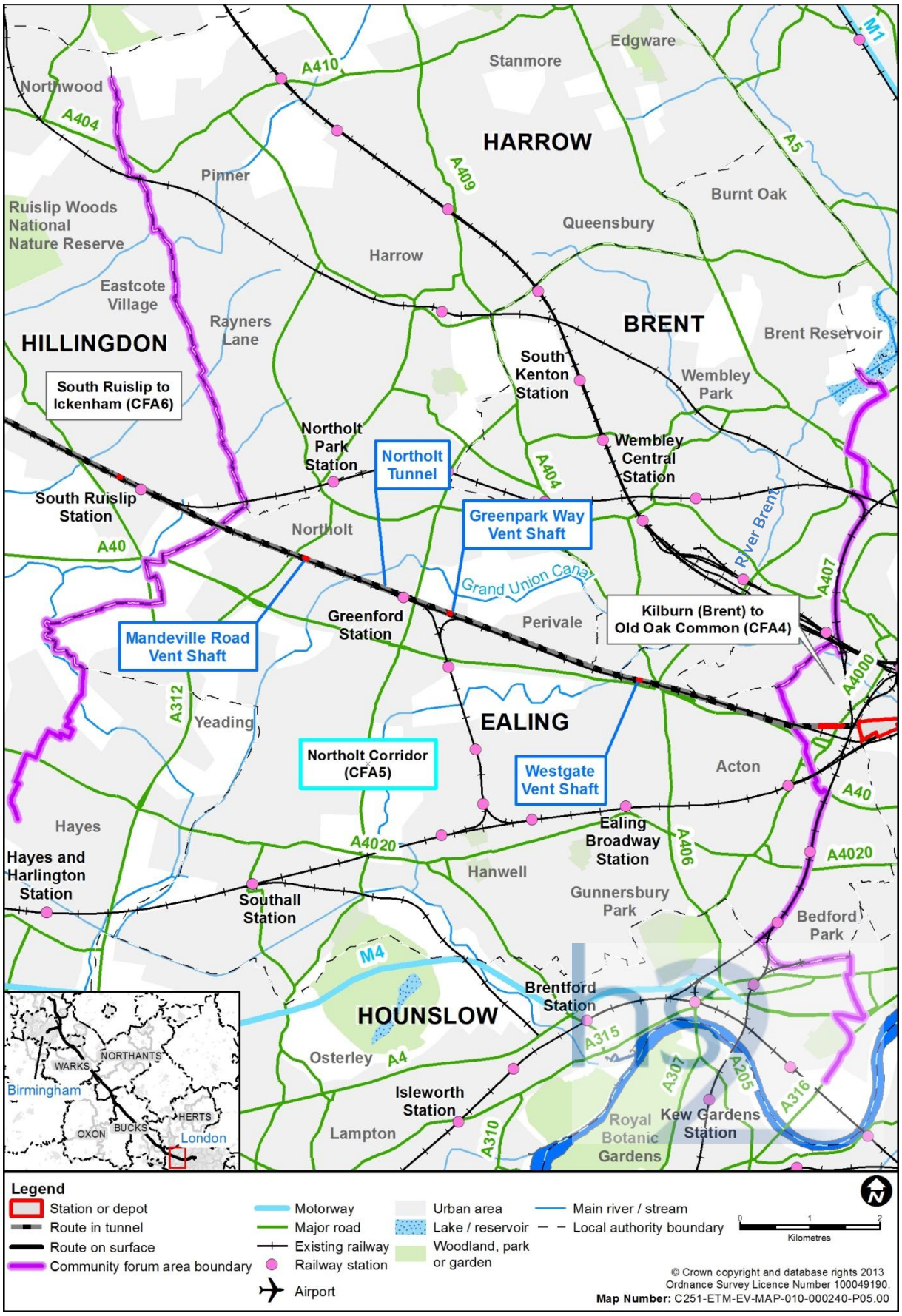
1.3.2 The study area extends to a distance of 500m from the centre line of the route and includes areas of the London Borough of Brent (LBB), LBE and London Borough of Harrow (LBHa). The study area includes the urban areas of North Acton, Perivale, Greenford and Northolt.

[1] Department for Communities and Local Government (2012), *National Planning Policy Framework.*

1.3.3 The route will cross two primary water bodies within the study area as identified using the surface water crossing (SWC) references on Map WR-01-005 and Map WR-01-006 (Volume 5, Water Resources and Flood Risk Assessment Map Book) including:

- the River Brent (SWC-CFA5-01); and
- the Grand Union Canal (Paddington Branch, SWC-CFA5-04).

Figure 1: Northolt Corridor area



2 Flood risk assessment methodology

2.1 Source-pathway-receptor model

2.1.1 Flood risk is assessed using the source-pathway-receptor model. In this model, individual sources of flooding within the study area are identified. The primary source of flooding is rainfall which is a direct source in the short-term (surface water flooding) and can lead to flooding from watercourses (river flooding) and overloaded man-made collection systems (sewer flooding) in the short or medium-term. Stored rainfall, either naturally in below ground aquifers and natural lakes or artificially in impounded reservoirs and canals, can lead to flooding when the storage capacity of the system is exceeded. A final source of flooding arises from tidal effects and storm surges caused by low pressure systems over the sea.

2.1.2 For there to be a risk of flooding at an individual receptor there must be a pathway linking it to the source of flooding. The pathways within the study area are assessed by reviewing national datasets that show the spatial distribution of flood risk. The associated risk magnitude is then categorised.

2.1.3 Receptors considered in this assessment include the Proposed Scheme and existing development within 500m of the Proposed Scheme. The Proposed Scheme includes all associated permanent infrastructure. Areas of interest are identified through comparison of the national spatial datasets with the design drawings. Where a risk is identified mitigation is proposed in line with recommendations in the NPPF.

2.1.4 Existing receptors within the study area are identified using Ordnance Survey (OS) mapping information. A high-level screening assessment is then undertaken to identify receptors that are within or in close proximity to an area of flood risk via pathways indicated using the flood risk data sources listed below. The vulnerability of each receptor is classified using Table 2 of the NPPF Technical Guidance Document[2].

2.1.5 The assessment then considers the vulnerability of the receptor with reference to the flood risk category of the source using Table 3 of the NPPF Technical Guidance Document and assesses whether the Proposed Scheme has any potential to influence or alter the risk of flooding to each receptor. Where such potential has been identified, mitigation is proposed based on further analysis.

2.2 Flood risk categories

2.2.1 The level of flood risk is categorised by assessing the design elements against the datasets for each source. A matrix showing the flood risk category associated with each flooding source is presented in Table 1.

[2] Department for Communities and Local Government (2012), *National Planning Policy Framework Technical Guidance.*

Table 1: Flood risk category matrix for all flooding sources

Source of flooding	Flood risk category				
	No risk	**Low**	**Medium**	**High**	**Very high**
Rivers		Flood Zone 1	Flood Zone 2	Flood Zone 3a	Flood Zone 3b
Surface water	No surface water flooding.	Surface water flooding <0.3m for 1 in 200 years event.	Surface water flooding >0.3m for 1 in 200 years event; and Surface water flooding <0.3m for 1 in 30 years event.	Surface water flooding >0.3m for 1 in 30 years event.	
Groundwater		Very low-low	Moderate	High-very high	
Drainage and sewer systems	No sewer in vicinity of site.	Surcharge point >20m from site and no pathways.	Surcharge point within 20m of site and restricted pathways.	Sewer network crosses site and pathways exist.	
Artificial sources	Outside of inundation mapping/no pathway exists.	Within inundation mapping/ pathway exists.			

2.3 Regional and local flooding planning policy documents

2.3.1 The lead local flood authorities (LLFA) for the study area are the LBE, LBB and LBHa. As unitary authorities, all are also the local planning authorities (LPA) for CFA5. The recommendations from the respective preliminary flood risk assessment (PFRA) reports, undertaken in accordance with the Flood Risk Regulations 2009[3], have been reviewed. Of the three councils LBB and LBHa have published surface water management plans. None of the councils has yet compiled a local flood risk management strategy (LFRMS).

2.3.2 In their capacity as the LPA each council has undertaken a strategic flood risk assessment (SFRA). All three boroughs are additionally covered by the London Regional Flood Risk Appraisal (RFRA).

London Borough of Ealing Preliminary Flood Risk Assessment

2.3.3 The LBE PFRA[4] indicates that there have been no identifiable past floods that have had significant harmful consequences. Future flood risk in the borough, however, is estimated to be high based on the Drain London surface modelling outputs.

[3] *Flood Risk Regulations 2009* (SI 2009 No.3042). London, Her Majesty's Stationery Office
[4] Capita Symonds (2011), *London Borough of Ealing Preliminary Flood Risk Assessment.*

2.3.4 The majority of the LBE, including the entire study area, lies within the Greater London indicative flood risk area. The LBE PFRA recommends redefining the extent of the indicative flood risk area such that the whole borough lies within it. Further stages of the Flood Risk Regulations 2009 process (i.e. flood risk mapping and flood risk management plans) will therefore be undertaken by the LLFA in due course. The LBE PFRA states that the current locally agreed spatial surface water flood risk information dataset is from the modelling activities undertaken as part of the Drain London project.

London Borough of Brent Preliminary Flood Risk Assessment

2.3.5 The LBB PFRA[5] indicates that there have been no identifiable past floods in the borough that have had significant harmful consequences under the indicative flood risk area significance criteria but noted the occurrence of flooding from surface water sewers in July 2007 and a number of recorded instances of groundwater flooding.

2.3.6 The whole of LBB lies within the Greater London indicative flood risk area. The LBB PFRA confirms that no modifications to the outline are required within the borough. Further steps of the Flood Risk Regulations 2009 process (i.e. flood risk mapping and flood risk management plans) will therefore be undertaken by the LLFA in due course. The LBB PFRA states that the current locally agreed spatial surface water flood risk information dataset is from the modelling activities undertaken as part of the Drain London project.

London Borough of Harrow Preliminary Flood Risk Assessment

2.3.7 The LBHa PFRA[6] indicates that there have been no identifiable past floods in the borough that have had significant harmful consequences under the indicative flood risk area significance criteria but noted the occurrence of several significant flooding events. None of these fall within the study area.

2.3.8 The whole of LBHa lies within the Greater London indicative flood risk area. The LBHa PFRA confirms that no modifications to the outline are required within the borough. Further steps of the Flood Risk Regulations 2009 process (i.e. flood risk mapping and flood risk management plans) will therefore be undertaken by the LLFA in due course. The LBHa PFRA states that the current locally agreed spatial surface water flood risk information dataset is from the modelling activities undertaken as part of the Drain London project.

Surface water management plans

2.3.9 Within the Drain London area surface water management plans will inform the LFRMS, which will ultimately guide the planning process in relation to flood risk across all categories and will outline key policies in relation to development within the area. LBE has not yet published a surface water management plan. LBB[7] and LBHa[8] surface water management plans have been reviewed. No construction for the Proposed Scheme will take place within the areas of influence of these plans. All surface water

[5] Hyder/AECOM (2011), *London Borough of Brent PFRA*.
[6] Hyder/AECOM (2011), *London Borough of Harrow PFRA*.
[7] Hyder/AECOM (2011), *London Borough of Brent Surface Water Management Plan Volume 1*.
[8] Hyder/AECOM (2011), *London Borough of Ealing Surface Water Management Plan Volume 1*.

management plans are being compiled as part of the Drain London Project and will all contain similar policy recommendations. Relevant policy recommendations contained within both of the published surface water management plans are as follows:

- the impact of development on existing infrastructure and drainage systems must be assessed and provisions made to reduce the current susceptibility to flooding across the borough. It is recommended that all development is required to attenuate flows to present greenfield runoff rates;
- development must be safe from flooding across its whole lifetime; and
- sustainable drainage systems (SuDS) should be used for all developments, including pollution controls. Sites over 0.5ha must include source control or surface storage within the site boundary and drainage should be entirely separate from foul drainage systems.

Thames Region Catchment Flood Management Plan

2.3.10 The Thames Region Catchment Flood Management Plan (CFMP)[9] sets out policies for the sustainable management of flood risk across the Thames catchment over the coming 50-100 years taking climate change into account. CFA5 lies within the TE2100 Policy Unit and the preferred policy within the CFMP for this study area is Policy 4. This includes areas of low, moderate or high risk where the Environment Agency is already managing the flood risk effectively but where further action may need to be taken to keep pace with climate change.

2.3.11 The Thames Region CFMP states that the most sustainable approach to managing future flood risk will be to bring about adaptation of the urban environment. It indicates that strategic scale planning is key to achieving the needs of the community and managing flood risk in a more sustainable way and that emergency planning is integral to the approach to managing extreme flood events.

London Regional Flood Risk Appraisal

2.3.12 The London Regional Flood Risk Appraisal (RFRA)[10] provides a broad regional understanding of the risk of flooding in Greater London to feed into each of the LLFA SFRA and PFRA reports. Recommendation 7 states that regeneration and redevelopment of London's river corridors offers a crucial opportunity to reduce flood risk in these areas.

London Borough of Ealing Strategic Flood Risk Assessment

2.3.13 The LBE SFRA[11] provides information on flooding in the borough and provides a supportive framework for assessing flood risk in planning policy. The LBE SFRA notes the susceptibility and historical occurrence of flooding from overloaded sewers within the borough, particularly within Northolt and Greenford, with recorded flood events in Acton during the 2007 flood event. The Brent corridor is noted to be a significant source of flooding. Groundwater flooding is considered to be a significant issue. The

[9] Environment Agency (2008), *Thames Catchment Flood Management Plan*.
[10] Greater London Authority (2009), *London Regional Flood Risk Appraisal.*
[11] Capita Symonds (2008), *London Borough of Ealing Strategic Flood Risk Assessment Volume 1 – Decision Support Document*.

risk is considered to be greatest along the Brent valley, in conjunction with the watercourse, and in the south of the borough, away from the study area.

2.3.14 Relevant policy recommendations within the LBE SFRA include the following:

- the use of SuDS to restrict surface runoff from development sites;
- achieve a positive reduction in the risk of flooding where possible;
- no development should increase flood risk;
- conveyance and storage should be improved in all systems; and
- all flow routes should be preserved.

London Borough of Brent Strategic Flood Risk Assessment

2.3.15 The LBB Level 1 SFRA[12] was completed in 2007. A Level 2 SFRA was undertaken for the Wembley masterplan area, however, this is north of the study area. The LBB SFRA acknowledges the high risk of surface water and sewer flooding in the area, but dismisses the risks of groundwater flooding as minimal. The LBB SFRA recommends that the council take a proactive approach to managing the risk of flooding in the borough by requiring positive contribution to reductions in the risk of flooding from developments.

London Borough of Harrow Strategic Flood Risk Assessment

2.3.16 The LBHa Level 1 SFRA[13] was completed in 2010. There are no areas at risk of river flooding within LBHa that also fall within the study area and consequently only the assessment of alternative sources is considered. The LBHa SFRA notes that surface water and sewer flooding are of particular concern within the borough. The majority of policy recommendations relate directly to the risk of flooding from rivers, however, the control of runoff from development sites and the incorporation of SuDS is recommended. The LBHa Level 2 SFRA[14], completed in 2011, focusses on the assessment of flood hazard from rivers and hence does not have specific relevance to the study area.

London Borough of Ealing Core Strategy

2.3.17 Policy 1.2 (m) of the LBE adopted Core Strategy[15] seeks to reduce the overall level of flood risk through the layout and form of new development and the appropriate application of sustainable drainage techniques. Under policies 5.2 and 5.3, metropolitan open land and green corridors will be sensitively managed for flood risk purposes.

London Borough of Brent Core Strategy

2.3.18 Policy CP19 of LBB adopted Core Strategy[16] sets out the policy of LBB on managing climate change in the borough. The policy specifically requires that all development

[12] Jacobs (2007), *London Borough of Brent Strategic Flood Risk Assessment.*
[13] MWH (2010), *London Borough of Harrow Strategic Flood Risk Assessment Level 1 Volume 1 – Planning and Policy Report*
[14] MWH (2011), *London Borough of Harrow Strategic Flood Risk Assessment Level 2.*
[15] London Borough of Ealing (2012), *Adopted Development (or Core) Strategy.*
[16] London Borough of Brent (2010), *Adopted Core Strategy.*

contributes towards mitigating and adapting towards climate change. The supporting text indicates that future development plan documents will include more detailed policies relating to the management of flood risk in the borough.

London Borough of Harrow Core Strategy

2.3.19 Policy CS1 of the LBHa adopted Core Strategy[17] seeks to manage development to achieve an overall reduction in flood risk and increase resilience to flood events.

[17] London Borough of Harrow (2012), *Adopted Core Strategy*.

3 Design criteria

3.1.1 It is a requirement of the design that the Proposed Scheme shall be protected against flooding from any source during the 1 in 1,000 years return period (0.1% annual probability) rainfall event, with water levels not rising closer than 1m to the top of rail level.

3.1.2 In accordance with the NPPF an allowance for climate change is included in the assessment by assuming that peak rainfall intensity will increase by 30% and that peak river flows will increase by 20%.

4 Data sources

4.1 Primary datasets

4.1.1 Consistent with the requirements of the NPPF, this assessment considers the risk of flooding from rivers, direct surface water runoff, rising groundwater, overwhelmed drainage and sewer systems, and artificial sources such as reservoirs, lakes and canals.

4.1.2 The Proposed Scheme lies entirely outside the extent of flooding from the sea and therefore the risk of flooding from tidal sources is not considered in this assessment.

4.1.3 The primary datasets for each source of flooding used to assess the design elements are presented in A high-level review of the risk of flooding and potential impacts is undertaken on the basis of these datasets across all flood sources. Where this review indicates potentially significant impacts on the risk of flooding, or a risk of flooding to the line, further investigation in the form of hydraulic modelling is undertaken.

4.1.4 Table 2. A high-level review of the risk of flooding and potential impacts is undertaken on the basis of these datasets across all flood sources. Where this review indicates potentially significant impacts on the risk of flooding, or a risk of flooding to the line, further investigation in the form of hydraulic modelling is undertaken.

Table 2: Flood risk assessment data sources

Source of flooding	Datasets reviewed	Data owner
Rivers	Flood zone mapping. Detailed River Network (DRN). Catchment hydraulic models.	Environment Agency
Surface water	Flood Map for Surface Water (FMfSW). Local surface water flood mapping.	Environment Agency LLFA
Groundwater	Areas susceptible to groundwater flooding. 1:50,000 geological mapping (superficial and bedrock). Potential for elevated groundwater.	British Geological Survey (BGS) LLFA
Drainage and sewer systems	Sewer network plans. Lost river location plans.	Water companies (various) Local planning authority
Artificial sources	Reservoir inundation mapping. Canal infrastructure locations. Trunk water main asset plans.	Environment Agency Canal & River Trust Water companies (various)

4.2 Site familiarisation visits

4.2.1 No site familiarisation visits have been undertaken within the study area.

5 The proposed development

5.1 Topography and land use

5.1.1 The topography within the study area is generally flat and variations in topography tend to be masked by overlying urban development. The area is predominantly suburban in character and includes the areas of Park Royal, Perivale, Greenford and Northolt.

5.1.2 The Grand Union Canal (Paddington Branch) passes through the area on an east-west axis, intersecting with the Proposed Scheme at the Kelvin Industrial Estate. The River Brent flows through the area in a north-east to south-west direction, intersecting with the Proposed Scheme near to the Manhattan Business Park.

5.1.3 The largest business park in London is located at Park Royal, to the north and south of the Proposed Scheme, with large areas of light industrial and commercial land uses. Perivale also has large light industrial land use areas. The open spaces at Horsenden Hill and Sudbury Golf Course lie to the north.

5.1.4 The London Underground (LU) Central Line is on an east-west axis between the boundary of CFA4 at Park Royal Road Bridge and CFA6 at Rabournmead Drive. Hanger Lane, Perivale, Greenford and Northolt Central Line stations and Greenford Network Rail (NR) Station are located within the study area. The A40 Western Avenue is immediately south of the Proposed Scheme.

5.2 Local flood risk receptors

5.2.1 The vulnerability of each local receptor with an identified pathway within the study area is presented in Table 3. The vulnerability is classified in accordance with the recommendations of Table 2 in the NPPF technical guidance document and the Scope and Methodology Report (SMR) (see Volume 5: Appendix CT-001-000/1) and the SMR Addendum (see Volume 5: Appendix CT-001-000/2).

Table 3: Vulnerability of local receptors in CFA5

Local receptor	Description	Vulnerability classification	Source/pathway
LU Central Line between North Acton and Hanger Lane	Railway corridor	More vulnerable	Surface water 30 years - deep
North Acton industrial area	Commercial developments and warehousing	Less vulnerable	Surface water 200yrs - shallow
Connell Crescent, Hanger Lane	Residential dwellings and associated infrastructure	More vulnerable	Surface water 200 years - shallow Groundwater – high
Hanger Lane junction	Transportation and commercial developments	Less vulnerable	Groundwater – very high
Properties north of Hanger Hill Park	Residential dwellings and associated infrastructure	More vulnerable	Surface water 30 years - deep

Local receptor	Description	Vulnerability classification	Source/pathway
West Gate industrial area	Commercial developments and warehousing	Less vulnerable	Surface water 30 years - deep Groundwater – very high
Riverside Gardens and Cleverley Crescent	Residential dwellings and associated infrastructure	More vulnerable	Flood Zone 3 Groundwater – very high
Quill Street industrial area	Commercial developments and warehousing	Less vulnerable	Flood Zone 2 Groundwater – very high
Pitshanger Park and football ground	Recreation and open space	Water compatible	Flood Zone 3 Groundwater – very high
Perivale Industrial Park	Commercial developments and warehousing	Less vulnerable	Surface water 30 years - deep
Bideford Avenue and adjacent properties	Residential dwellings and associated infrastructure	More vulnerable	Surface water 30 years - deep
Selbourne Gardens and adjacent properties	Residential dwellings and associated infrastructure	More vulnerable	Surface water 200 years - deep
Ealing Central Sports Ground	Recreation/open space	Water compatible	Surface water 200 years - shallow
Perivale Station access at Horsenden Lane South	Railway infrastructure and access	More vulnerable	Surface water 30 years - deep
Conway Crescent and adjacent properties	Residential dwellings and associated infrastructure	More vulnerable	Surface water 200 years - deep
Greenpark Way Industrial Estate	Commercial developments and warehousing	Less vulnerable	Surface water 200 years - deep
Greenford Road and adjacent properties	Residential dwellings and associated infrastructure	More vulnerable	Surface water 200 years - shallow Groundwater – very high
Carr Road and Castle Road, Northolt	Residential dwellings and associated infrastructure	More vulnerable	Surface water 30 years - deep
Kelvin Industrial Estate	Commercial developments and warehousing	Less vulnerable	Surface water 30 years - deep
Northolt Station and adjacent tracks	Railway infrastructure	More vulnerable	Surface water 30 years - deep
Mandeville Road and adjacent properties	Residential dwellings and associated infrastructure	More vulnerable	Surface water 200 years - deep
Arnold Road and adjacent properties	Residential dwellings and associated infrastructure	More vulnerable	Surface water 200 years - shallow
Northolt High School	Educational establishment	More vulnerable	Surface water 200 years - deep

5.3 Description of the Proposed Scheme

5.3.1 The Proposed Scheme through the Northolt Corridor area will be 8.7km in length and, with the exception of three ventilation and intervention shafts, will be entirely in tunnel.

5.3.2 The route will run in tunnel from Park Royal Road, with vent shafts at Westgate, Greenpark Way and Mandeville Road, before continuing beneath the route of the LU Central Line to the boundary with CFA6 to the south of Rabournmead Drive.

5.3.3 The vent shaft site at Westgate will be located on the site of an existing builder's merchant (see Map CT-06-011 (Volume 2, CFA5 Map Book)). The surrounding area comprises office buildings with AGB House to the north-east, Westgate House to the east, Manhattan Business Park to the west and West World located to the north-west.

5.3.4 The vent shaft site at Greenpark Way will be located on vacant land within an existing business park, east of the A4127 Greenford Road on the northern side of the LU Central Line (see Map CT-06-013 (Volume 2, CFA5 Map Book)).

5.3.5 The vent shaft site at Mandeville Road is an existing railway cutting slope approximately 150m east of the A312 Mandeville Road, on the northern side of the LU Central Line (Map CT-06-014 (Volume 2, CFA5 Map Book)).

5.3.6 Shaft headhouse buildings will be located above the three shafts.

5.3.7 Permanent features are shown on Map CT-06-09 to Map CT-06-15 (Volume 2, CFA5 Map Book).

6 Existing flood risk

6.1 Historical flooding incidents

6.1.1 None of the PFRA reports within the study area have identified past floods that have had significant harmful consequences, which would be reportable to the European Union (EU).

6.1.2 The River Brent is reported to have flooded both upstream of the study area, close to the crossing of the A4005 Hanger Lane, and downstream of the study area within Perivale Park Golf Course. These areas of historical flooding are shown on Map WR-01-005, E5 and B7-B8 (Volume 5, Water Resources and Flood Risk Assessment Map Book).

6.1.3 The LBE SFRA identifies a number of historical surface water and sewer flooding events. A total of 140 properties have flooded in Ealing from the foul water drainage systems and 30 properties have flooded as a result of surcharging of surface water sewers in the past 10 years, with a further 135 properties affected by flooding from combined systems in the same time period. The majority of these incidents are in Acton, south of the Proposed Scheme. Of these, approximately 235 properties lie within the study area.

6.1.4 The LBE PFRA identifies a number of groundwater flooding incidents within the borough, with some located within the study area to the south-east of Hanger Lane Station.

6.2 Risk of flooding from rivers

6.2.1 The route will cross the River Brent in tunnel to the west of Hanger Lane, as shown on Map CT-06-11, C6 (Volume 2, CFA5 Map Book). The River Brent has a catchment size of 128km^2 at the crossing of the route, resulting in 1 in 100 years return period (1% annual probability) flood flows of approximately 164m^3/s (calculated using the Revitalised Flood Hydrograph, or ReFH, method). The centre line of the route will pass in tunnel below approximately 20m of Flood Zone 2 and 3. The Environment Agency has provided detailed hydraulic modelling of the River Brent. Upstream of the existing railway line for approximately 360m, Flood Zone 2 and Flood Zone 3 are constrained by high ground on the left and right bank.

6.2.2 All three proposed vent shafts within CFA5 will be located in Flood Zone 1, with threshold levels at the Westgate vent shaft (closest to the watercourse) set above the modelled 1 in 1,000 years return period (0.1% annual probability) flood water level of the River Brent. There will be no risk of river flooding to the Proposed Scheme within CFA5.

6.3 Risk of flooding from surface water

6.3.1 The Drain London modelling outputs and the Environment Agency FMfSW have been reviewed to form the basis of the assessment of the risk of surface water flooding. In general LLFAs are reporting a good correlation between the FMfSW and the Drain London modelling; the Drain London modelling, however, considers the underground

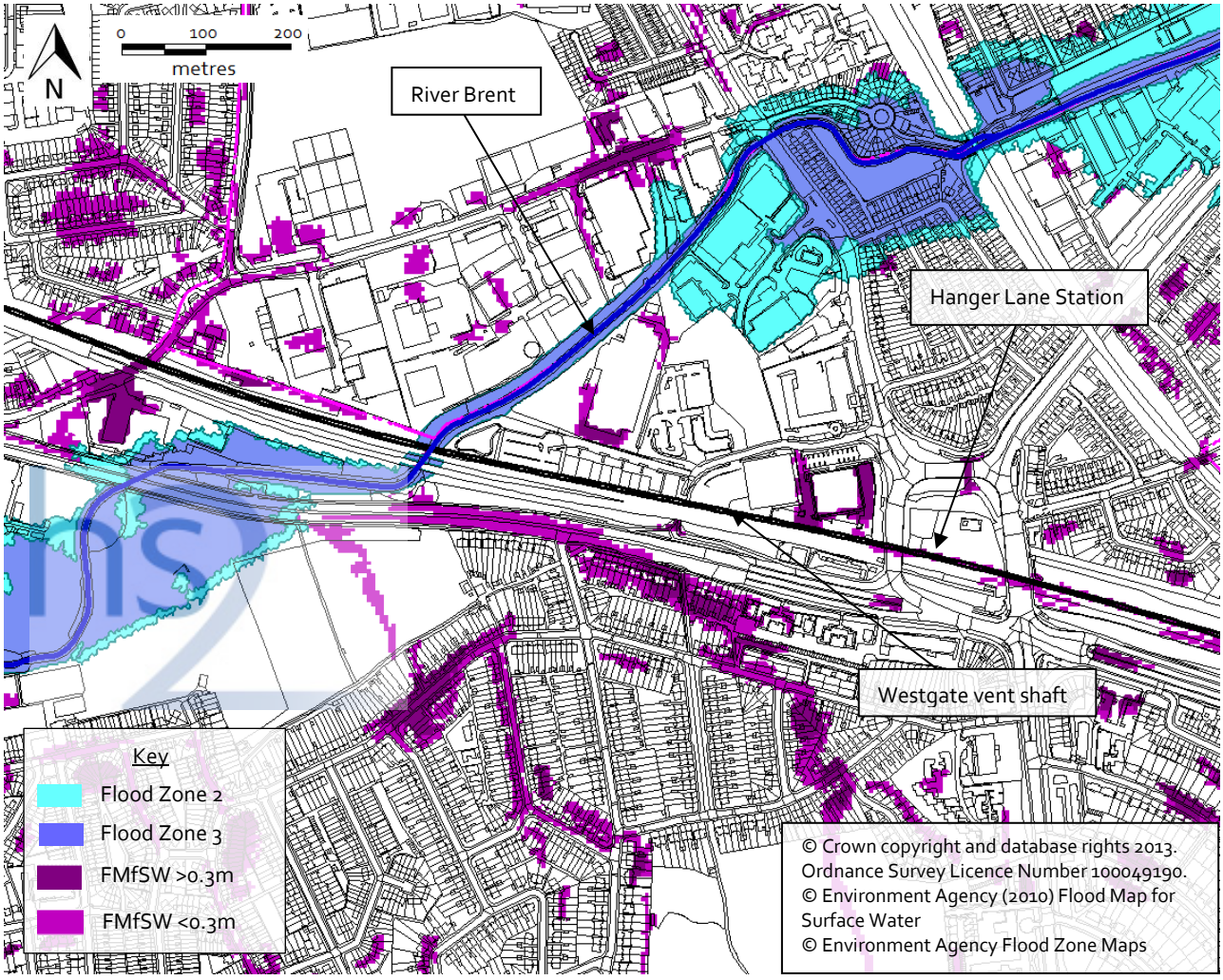
drainage infrastructure in a greater level of detail and is therefore a superior dataset. The FMfSW for the 1 in 200 years return period (0.5% annual probability) flood event is shown on Map WR-01-005.

6.3.2 According to the combined surface water flood risk datasets, there are areas within the study area that have a high risk of surface water flooding. Since the route will be within tunnel for the majority of the study area, however, the surface water flood risk has been considered only in the location of permanent above-ground infrastructure.

Westgate vent shaft

6.3.3 Surface water flooding datasets show areas to the west of Hanger Lane and to the south of the A40 and LU Central Line to be at risk of flooding during the 1 in 200 years return period (0.5% annual probability) flood event to a depth greater than 0.3m, as shown in Figure 2. The Westgate vent shaft will be located to the north of the LU Central Line, as shown on Map CT-06-11, E6 (Volume 2, CFA5 Map Book), approximately 45m from the closest area at risk of surface water flooding. There are no flood pathways shown to cross the site.

Figure 2: 1 in 200 years return period (0.5% annual probability) surface water flood depth and flood zones at the Westgate vent shaft



6.3.4 Based on light detection and ranging (LiDAR) information, the ground level at the location of the vent shaft is around 29.5m above Ordnance Datum (AOD). The threshold level for the proposed shaft will be 28.5m AOD. The extent of the predicted surface water flooding suggest that the flood level is approximately 29m AOD around Westec House to the east of the proposed vent shaft, and 28m AOD along Western Avenue to the south of the vent shaft. Both areas of flooding are located away from the site of the proposed shaft, however, with ground level gradients falling to the north and west respectively, directing floodwaters away from the site. Consequently, there will be no significant risk of surface water flooding to the Proposed Scheme at the Westgate vent shaft.

Greenpark Way vent shaft

6.3.5 The surface water flooding datasets show isolated areas in the Rockware Industrial Estate to be at risk of flooding during the 1 in 200 years return period (0.5% annual probability) flood event as shown in Figure 3. Depths of flooding are shown to be greater than 0.3m in some locations. The Greenpark Way vent shaft will be located to the north of the existing LU Central Line, as shown on Map CT-06-13, G6 (Volume 2, CFA5 Map Book), approximately 25m from the closest area at risk of surface water flooding.

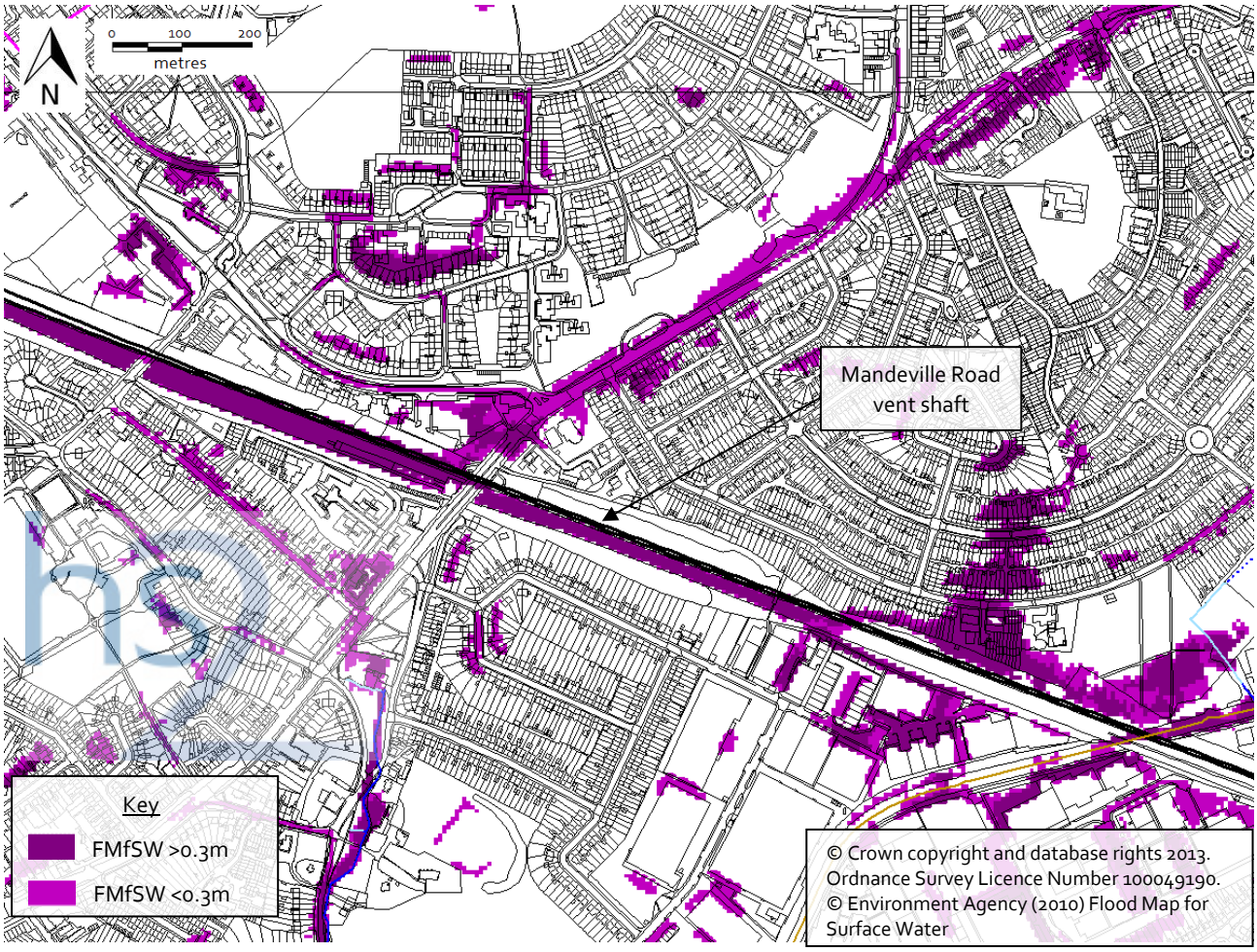
Figure 3: 1 in 200 years return period (0.5% annual probability) surface water flood depths and flood zones at Greenpark Way vent shaft

6.3.6 Based on LiDAR information, the ground level at the location of the vent shaft is between 27m AOD and 28m AOD. The threshold level for the proposed shaft will be 27.7m AOD. The extent of the predicted surface water flooding suggests that the flood level is approximately 26.5m AOD around the units on Rockware Avenue and 26.5m AOD on Lyon Way, south of the vent shaft location. There will therefore be no significant risk of surface water flooding to the Proposed Scheme at the Greenpark Way vent shaft.

Mandeville Road vent shaft

6.3.7 The surface water flooding datasets show the track bed of the LU Central Line to the east and west of Northolt Station to be at risk of flooding during the 1 in 200 years return period (0.5% annual probability) flood event as shown in Figure 4. The maximum predicted depth of surface water flooding is greater than 0.3m. For higher probability events, the Central Line is shown to be at risk of flooding, with depths greater than 0.3m to the west of Northolt Station but less than 0.1m to the east of Northolt Station. The Mandeville Road vent shaft will be located to the north of the LU Central Line, as shown on Map CT-06-14, D6 (Volume 2, CFA5 Map Book), approximately 5m from the closest area at risk of surface water flooding.

Figure 4: 1 in 200 years return period (0.5% annual probability) surface water flood depths at Mandeville Road vent shaft



6.3.8 Based on LiDAR information, the proposed vent shaft site is located on a steep bank down to the LU Central Line cutting. The ground level at the lowest point on the site boundary is 38m AOD and rises to 45m AOD. The threshold level for the proposed shaft will be 44m AOD. The extent of the predicted surface water flooding suggests a maximum flood water level in the cutting of 38m AOD and there will therefore be a freeboard of at least 6m between the 1 in 200 years return period (0.5% annual probability) flood water level and the minimum threshold of the proposed vent shaft. There will therefore be no significant risk of surface water flooding to the Proposed Scheme at the Mandeville Road vent shaft.

6.4 Risk of flooding from groundwater

6.4.1 Along the River Brent valley there are potentially water-bearing superficial deposits comprising alluvium and river terrace deposits (Taplow Gravel and Kempton Park Gravel) associated with the river and floodplain corridor. Shallow groundwater is likely to be in continuity with surface water in the River Brent. A further narrow ribbon of alluvial deposits is also present in the western part of the study area, along Greenford Road, which is associated with a now culverted stream locally referred to as the Bulibrook. The bedrock geology underlying the study area is the London Clay Formation, which, for the most part comprises the low permeability London Clay. There is, however, a small outcrop in the south-west, around Hanger Lane, of the more permeable upper strata of the London Clay Formation comprising the Claygate Beds (a Secondary A designated aquifer).

6.4.2 The LBE SFRA notes that groundwater flooding is not considered a significant issue, although the groundwater risk overview map shows 'medium' and 'high' risk along the River Brent corridor.

6.4.3 The LBE PFRA indicates that the Proposed Route will intersect two areas that have an increased potential for elevated groundwater in the study area, as follows:

- within the superficial alluvial deposits of the River Brent, where the route will be in tunnel; and
- within the superficial alluvial deposits around Greenford Road, where the route will be in tunnel.

6.4.4 In addition, the BGS groundwater flooding susceptibility map shows that there is a 'high' susceptibility of groundwater flooding at Hanger Lane, arising from the Claygate Beds bedrock aquifer.

6.4.5 The route will be in tunnel through all areas at risk of flooding from groundwater and in general below the top of the London Clay bedrock or within the underlying Lambeth Group Formation, i.e. below the shallow groundwater table within the superficial deposits or Claygate Beds.

6.4.6 The Westgate vent shaft will be located approximately 20m from the extent of the area shown to have an increased potential for elevated groundwater along the River Brent valley, within the shallow Taplow Gravel Formation. Groundwater flooding arising from this source would flow overland to the River Brent, away from the vent shaft site. Any emergent groundwater in the Hanger Lane area will flow overland in a

north-westerly direction towards the River Brent, away from the proposed vent shaft. The remaining vent shafts will not be located within areas that are shown to be susceptible to groundwater flooding.

6.4.7 There will therefore be no significant risk of groundwater flooding to the Proposed Scheme within CFA5.

6.5 Risk of flooding from drainage systems

6.5.1 The route will pass below a number of urban centres within the study area and therefore above ground infrastructure will be located close to the existing public sewer network and associated manholes. The PFRA and SFRA within the study area have reported a number of historical incidents of sewer flooding, however, the exact location of these events is not available.

6.5.2 The existing public sewer network in this area is predominantly combined (i.e. sewers collect both foul water and surface water) and therefore the risk of flooding from sewers is considered to be comparable to the risk of flooding from surface water sources that has been previously described in Section 6.3 of this report.

6.5.3 There will therefore be no significant risk of flooding from drainage and sewer systems to the Proposed Scheme within CFA5, in addition to that specified in Section 6.3 of this report.

6.6 Risk of flooding from artificial sources

Grand Union Canal (Paddington Branch)

6.6.1 The route will cross under the Grand Union Canal (Paddington Branch) between Greenford and Northolt, as shown on Map CT-06-14, H6 (Volume 2, CFA5 Map Book). The canal is at or below ground level at the intersection with the Proposed Scheme. At this location, the route will be in twin bored tunnels that are approximately 44m below ground level and therefore there will be no significant risk of flooding to the Northolt tunnel from the Grand Union Canal (Paddington Branch) at the crossing location.

6.6.2 The Ealing SFRA states that flooding as a result of a breach of the Grand Union Canal (Paddington Branch) to the east of the crossing location will either follow the channel of the River Brent, or will flow towards the North Circular Road which the canal crosses on an aqueduct.

6.6.3 The Greenpark Way vent shaft will be located approximately 250m to the south of the Grand Union Canal (Paddington Branch), as shown on Map CT-06-13, G4 (Volume 2, CFA5 Map Book). Existing ground levels at the location of the shaft are approximately 28m AOD. The banks of the canal are bunded with embankments of up to 2m in height, to around 30m AOD, however the managed water level is at or close to ground level. As a result, there is no significant risk of a breach causing flooding in the area. Further, ground levels fall from 31m AOD north-east of the vent shaft site in a north-westerly direction away from the vent shaft site to a minimum level of 26m AOD. It is likely that any flooding arising from the Grand Union Canal (Paddington Branch) would therefore be directed away from the proposed vent shaft location. There will be

no significant risk of flooding to the Proposed Scheme from the Grand Union Canal (Paddington Branch) at the Greenpark Way vent shaft.

Reservoirs

6.6.4 The route will cross an area that is shown in the Environment Agency Reservoir Inundation Maps to be at risk of flooding in the event of failure of the Brent Reservoir (Welsh Harp) at the crossing of the River Brent, as shown on Map WR-01-005, E6 (Volume 5, Water Resources and Flood Risk Assessment Map Book). This reservoir is owned and managed by the Canal & River Trust and its primary outfall is the River Brent.

6.6.5 The Reservoirs Act 1975[18] (as amended by the Flood and Water Management Act 2010[19]) requires reservoir owners to maintain retaining structures such that the annual probability of a breach of the reservoir is 1 in 50,000.

6.6.6 There will be no above ground construction within the area shown to be at risk from this source and there will therefore be no significant risk of flooding to the Proposed Scheme.

Water Mains

6.6.7 The route will cross in tunnel below a number of Thames Water Utilities Limited (TWUL) water supply mains in the eastern half of the study area. Water supply mains in the west of the study area are owned by Affinity Water. Where the route will be in tunnel, with no above ground infrastructure, there will be no significant risk of flooding to the Proposed Scheme.

6.6.8 To the west of the Westgate vent shaft, the route will cross below a 686mm diameter cast iron water supply main. The invert level of this main is not known. The ground level at the location of the water main is approximately 27.0m AOD and the threshold level of the Westgate vent shaft will be 28.5m AOD. Any flooding arising from failure of this water main will therefore flow down gradient away from the proposed vent shaft location.

6.6.9 The locations of further water mains within the study area under the ownership of Affinity Water have not been provided and have therefore not been reviewed. Ground level information, however, suggests that the three vent shafts are generally located above surrounding ground and the risk of flooding is therefore low. There will be no significant risk of flooding to the Proposed Scheme from water mains.

[18] *Reservoirs Act 1975* (c.23). London, Her Majesty's Stationery Office.
[19] *Flood and Water Management Act 2010* (c.29). London, Her Majesty's Stationery Office.

6.7 Summary of baseline flood risk

Table 4: Summary of baseline flood risk for all sources of flooding in CFA5

Source of flooding	Location of flooding source	Flood risk category	Elements at risk	Assessment of risk
Rivers	River Brent	High Flood Zone 3	Northolt tunnel	Route will be in tunnel - no risk
Surface water	West Gate industrial area	High Drain London 30 years - deep	Westgate vent shaft	Element will not be located within surface water flow paths - no risk
			Northolt tunnel	Route will be in tunnel - no risk
Surface water	Westway Retail Park area	Medium Drain London 30 years - shallow	Greenpark Way vent shaft	Element will not be located within surface water flow paths - no risk
			Northolt tunnel	Route will be in tunnel - no risk
Surface water	LU Central Line cutting	High Drain London 30 years - deep	Mandeville Road vent shaft	Element will be >1m above water level - no risk
			Northolt tunnel	Proposed Scheme will be in tunnel - no risk
Groundwater	Claygate Beds near Hanger Lane gyratory	High Groundwater– very high	Northolt tunnel	Tunnel will be below geological formation – no risk
Groundwater	River Brent corridor superficial deposits	High Groundwater– very high	Westgate vent shaft	Element will be >1m above ground level in area at risk – no risk
			Northolt tunnel	Tunnel will be below geological formation – no risk
Groundwater	Alluvial deposits along Greenford Road	High Groundwater– very high	Northolt tunnel	Tunnel will be below geological formation – no risk
Artificial sources	Brent (Welsh Harp) reservoir	Low Within mapped inundation area	Euston tunnel	Route will be in tunnel - no risk

7 Flood risk management measures

7.1 Risk of flooding from rivers

7.1.1 There will be no risk of flooding from rivers to the Proposed Scheme, nor any anticipated effects on the risks of flooding from rivers within the study area arising from the Proposed Scheme. Therefore, no specific mitigation will be required.

7.2 Risk of flooding from surface water

7.2.1 Surface water runoff from the Proposed Scheme will be managed by attenuating peak runoff rates from above ground infrastructure before discharging to TWUL sewers at restricted rates.

7.2.2 There will not be a significant risk of flooding from surface water sources to the Proposed Scheme within CFA5. Therefore, no specific mitigation will be required.

7.3 Risk of flooding from groundwater

7.3.1 There will be no risk of flooding from groundwater to the Proposed Scheme, nor any anticipated effects on the risks of flooding from groundwater within the study area arising from the Proposed Scheme. Therefore, no specific mitigation will be required.

7.4 Risk of flooding from drainage systems

7.4.1 There will be no risk of flooding from drainage systems to the Proposed Scheme, nor any anticipated effects on the risks of flooding from drainage systems within the study area arising from the Proposed Scheme. Therefore, no specific mitigation will be required.

7.5 Risk of flooding from artificial sources

7.5.1 There are no instances where the Proposed Scheme will be at significant risk of flooding from artificial sources within CFA5. There will be no significant effects on the risk of flooding from artificial sources (Grand Union Canal, Brent Reservoir or Water Mains) arising from the Proposed Scheme within CFA5. Therefore, no specific mitigation will be required.

8 Post-development flood risk assessment

8.1 Local receptors

8.1.1 In addition to the risk of flooding that exists to the Proposed Scheme, there is potential for the Proposed Scheme to affect the risk of flooding to third party receptors by altering flow mechanics across the range of flood sources. All local receptors with a potential flood risk are identified in Section 5.2 of this report. For the Proposed Scheme to have an impact on a given receptor, the identified pathway for that receptor must be shared by both the subject receptor and the Proposed Scheme, with the result that a number of cases can be excluded immediately. Table 5 summarises the shared pathways between the Proposed Scheme and each receptor, and identifies cases where no shared pathway exists.

Table 5: Shared flood risk pathways in CFA5

Local receptor	**Vulnerability classification as per the NPPF**	**Pathway**	**Shared pathway between Proposed Scheme and receptor**
LU Central Line between North Acton and Hanger Lane	More vulnerable	Surface water 30 years - deep.	No shared pathway.
North Acton industrial area	Less vulnerable	Surface water 200 years - shallow.	No shared pathway.
Connell Crescent, Hanger Lane	More vulnerable	Surface water 200 years - shallow Groundwater - high	Groundwater only - Northolt tunnel.
Hanger Lane junction	Less vulnerable	Groundwater – very high	Northolt tunnel.
Properties north of Hanger Hill Park	More vulnerable	Surface water 30 years - deep.	No shared pathway.
West Gate industrial area	Less vulnerable	Surface water 30 years - deep Groundwater – very high	Westgate vent shaft. Northolt tunnel.
Riverside Gardens and Cleverley Crescent	More vulnerable	Flood Zone 3 Groundwater – very high	No shared pathway.
Quill Street industrial area	Less vulnerable	Flood Zone 2 Groundwater – very high	Groundwater only - Northolt tunnel.
Pitshanger Park and football ground	Water compatible	Flood Zone 3 Groundwater – very high	Groundwater only - Northolt tunnel.
Perivale Industrial Park	Less vulnerable	Surface water 30 years - deep	No shared pathway.
Bideford Avenue and adjacent properties	More vulnerable	Surface water 30 years - deep	No shared pathway.
Selbourne Gardens and adjacent properties	More vulnerable	Surface water 30 years - deep	No shared pathway.

Local receptor	Vulnerability classification as per the NPPF	Pathway	Shared pathway between Proposed Scheme and receptor
Ealing Central sports ground	Water compatible	Surface water 200 years - shallow	No shared pathway.
Perivale Station access at Horsenden Lane South	More vulnerable	Surface water 30 years - deep	No shared pathway.
Conway Crescent and adjacent properties	More vulnerable	Surface water 200 years - deep	No shared pathway.
Greenpark Way industrial estate	Less vulnerable	Surface water 200 years - deep	Greenpark Way vent shaft.
Greenford Road and adjacent properties	More vulnerable	Surface water 200 years - shallow Groundwater – very high	Groundwater only - Northolt tunnel.
Carr Road and Castle Road, Northolt	More vulnerable	Surface water 30 years - deep	No shared pathway.
Kelvin industrial estate	Less vulnerable	Surface water 200 years - deep	No shared pathway.
Northolt Station and adjacent tracks	More vulnerable	Surface water 30 years - deep	Mandeville Road vent shaft.
Arnold Road and adjacent properties	More vulnerable	Surface water 200 years - shallow	No shared pathway.
Northolt High School	More vulnerable	Surface water 200 years - deep	No shared pathway.

8.1.2 There is also the potential for the Proposed Scheme to change the baseline risk of flooding described in the Section 6 of this report. Though designed such that the probability of the Proposed Scheme flooding in any given year is less than 1 in 1,000, any change to the baseline risk of flooding could impact on the assessment of flood risk to the Proposed Scheme. All cases of flood risk discussed in Section 6 of this report are therefore reconsidered regardless of the presence or otherwise of third party local receptors.

8.2 Impact on risk of flooding from rivers

8.2.1 The Proposed Scheme will be in tunnel where it will cross below the floodplain of the River Brent, with no above ground construction proposed within the floodplain. Therefore the Proposed Scheme will not change the risk of flooding at this location. There are no further river crossings where the Proposed Scheme could affect the risk of river flooding.

8.3 Impact on risk of flooding from surface water

8.3.1 Any above ground infrastructure has the potential to alter overland flow routes, thereby changing the risk of flooding to local receptors through displacement of flood waters and alteration to flow conveyance times. The three proposed vent shafts within CFA5 will lie close to areas of significant surface water flood risk and therefore will have the potential to alter the risk of flooding in the area.

Westgate vent shaft

8.3.2 Above ground construction at the Westgate vent shaft will be confined to the area bounded by Westgate to the north and the existing LU Central Line to the south. There will be no construction within the area at risk of surface water flooding and there will therefore be no impact due to alteration of overland flow routes on the risk of surface water flooding in the area arising from the proposed vent shaft.

8.3.3 Surface water will be collected and attenuated prior to discharge at an assumed rate of 34l/s to the existing TWUL 525mm diameter sewer on Westgate road. Attenuation volumes up to a maximum of 450m^3 are proposed in the vicinity of the shaft, to attenuate storms up to the 1 in 100 years return period (1% annual probability) rainfall event including an allowance for climate change. Any connection and allowable discharge rates will be agreed in advance with TWUL.

8.3.4 The Proposed Scheme will not significantly affect the risk of surface water flooding at or in the vicinity of the Westgate vent shaft. The risk of flooding to receptors within the adjacent industrial park will not be affected by the Proposed Scheme.

Greenpark Way vent shaft

8.3.5 Above ground construction at the Greenpark Way vent shaft will be confined to the area bounded by the existing LU Central Line to the south and Greenpark Way to the north. There will be no construction within the area at risk of surface water flooding and there will therefore be no impact due to alteration of overland flow routes on the risk of surface water flooding in the area arising from the proposed vent shaft.

8.3.6 Surface water will be collected and attenuated prior to discharge at an assumed rate of 34l/s to the existing TWUL sewers on Rockware Avenue. Attenuation volumes up to a maximum of 410m^3 are proposed in the vicinity of the shaft to attenuate storms up to the 1 in 100 years return period (1% annual probability) rainfall event including an allowance for climate change. Any connection and allowable discharge rates will be agreed in advance with TWUL.

8.3.7 The Proposed Scheme will not significantly affect the risk of surface water flooding at or in the vicinity of the Greenpark Way vent shaft. The risk of flooding to receptors within the Westway retail park will not be affected by the Proposed Scheme.

Mandeville Road vent shaft

8.3.8 Above ground construction at the Mandeville Road vent shaft will be confined to the area bounded by the existing LU Central Line to the south and Badminton Close to the north. There will be no construction within the area at risk of surface water flooding and there will therefore be no impact due to alteration of overland flow routes on the risk of surface water flooding in the area arising from the proposed vent shaft.

8.3.9 Surface water will be collected and attenuated prior to discharge at an assumed rate of 34l/s to the existing TWUL 900mm diameter sewer on Mandeville Road. Attenuation volumes up to a maximum of 340m^3 are proposed in the vicinity of the shaft, to attenuate storms up to the 1 in 100 years return period (1% annual probability) rainfall event including an allowance for climate change. Any connection and allowable discharge rates will be agreed in advance with TWUL.

8.3.10 The Proposed Scheme will not significantly affect the risk of surface water flooding at or in the vicinity of the Mandeville Road vent shaft.

8.4 Impact on risk of flooding from groundwater

8.4.1 The Proposed Scheme will be below both the superficial deposits and the water bearing Claygate Beds strata within CFA5. There will therefore be no impact on groundwater levels and consequently no effect on the risk of flooding from groundwater within the study area.

8.5 Impact on risk of flooding from drainage systems

8.5.1 Connections to the foul and surface water sewer network from the shaft headhouses within CFA5 will be agreed with TWUL in order to avoid creating additional burden on the existing sewer networks. There will not be a significant increase in the area of impermeable surface following construction as the sites are currently developed. The Proposed Scheme will therefore not lead to a change in the risk of flooding from drainage and sewer systems within the study area.

8.6 Impact on risk of flooding from artificial sources

Canals

8.6.1 The route will be in tunnel beneath the Grand Union Canal (Paddington Branch). The canal is at ground level in the vicinity of the Proposed Scheme and approximately 140m of the canal lies within the predicted 1mm settlement contour of the Northolt tunnel. As the canal is at ground level there will be no risk of water from the canal escaping to the surface. The Proposed Scheme will therefore not lead to a permanent change in the risk of flooding from canals.

Brent (Welsh Harp) Reservoir

8.6.2 The route will be in tunnel where it will cross the area at risk of flooding in the event of failure of the Welsh Harp reservoir. No above ground construction is proposed within the area at risk and there will therefore be no effect on the risk of flooding from this source as a result of the Proposed Scheme.

Water mains

8.6.3 The settlement of the ground along the length of all water mains due to tunnelling and the potential damage to the pipes due to additional strain in the material will be assessed prior to and during construction. Although an increased risk of failure exists during construction, this will be managed as part of the construction program. So long as the construction risks are appropriately managed, the risk of failure of these water mains in the permanent case will not be increased as a result of the Proposed Scheme.

8.7 Summary of potential impacts and effects on flood risk

Table 6: Summary of potential flood risk impacts and effects in CFA5

Receptor	Vulnerability classification	Pathway	Impacts and effects
General Proposed Scheme	N/A	Rivers	No effects expected.
		Surface water	No above ground construction within areas at risk and rainfall to be collected, attenuated and discharged to existing public sewer network. No significant effects expected.
		Groundwater	No effects expected.
		Drainage systems	Surface and foul discharges at vent shafts to be collected, attenuated and discharged to existing public sewer network. No significant effects expected.
		Artificial sources	No effects expected.
Connell Crescent, Hanger Lane	More vulnerable	Groundwater – high	Northolt tunnel will be below the Claygate Beds. No effects expected.
Hanger Lane junction	Less vulnerable	Groundwater – very high	Northolt tunnel will be below the Claygate Beds. No effects expected.
West Gate industrial area	Less vulnerable	Surface water 30 years - deep Groundwater – very high	Westgate vent shaft will not displace flood waters or obstruct flood flows. No effects expected. Northolt tunnel will be below the Claygate Beds and superficial deposits. No effects expected.
Quill Street industrial area	Less vulnerable	Groundwater – very high	Northolt tunnel will be below the superficial deposits. No effects expected.
Pitshanger Park and football ground	Water compatible	Groundwater – very high	Northolt tunnel will be below the superficial deposits. No effects expected.
Greenpark Way industrial estate	Less vulnerable	Surface water 200 years - deep	Greenpark Way vent shaft will not displace flood waters or obstruct flood flows. No effects expected.
Greenford Road and adjacent properties	More vulnerable	Groundwater – very high	Northolt tunnel will be below the superficial deposits. No effects expected.
Northolt Station and adjacent tracks	More vulnerable	Surface water 30 years - deep	Mandeville Road vent shaft will not displace flood waters or obstruct flood flows. No effects expected.

9 Conclusions

9.1 Summary

9.1.1 The Proposed Scheme within CFA5 extends from Park Royal Road Bridge to the boundary of the London Borough of Ealing with the London Borough of Hillingdon. The study area covers 500m of the route, which includes areas at risk of flooding from the following sources:

- areas at risk of flooding from the River Brent;
- areas at risk of surface water flooding in North Acton, Perivale, Greenford and Northolt;
- areas with a susceptibility to groundwater flooding at Hanger Lane, the crossing of the River Brent, and Greenford Road; and
- areas at risk of flooding in the event of failure of the Brent Reservoir and trunk water mains.

9.1.2 The Proposed Scheme will be in tunnel or at least 1m above design flood water levels within all areas at risk of flooding. Residual risks from these sources will be negligible.

9.1.3 CFA5 is heavily urbanised, with substantial residential and industrial areas within the study area. There are areas at risk of flooding as a result of surface water runoff in rainfall events, as well as overloaded sewers and failed water mains. All above ground construction lies outside of the areas at risk and consequently will have no direct impact on the risk of flooding. Surface water runoff at the vent shafts will be collected, attenuated and discharged to existing sewers at pre-agreed rates and will not create an additional burden on the existing drainage infrastructure. The condition of trunk sewers and water mains will be monitored prior to and during construction to ensure no increased risk of failure due to settlement arising from the proposed tunnels. There will be no increased risk of failure to underground surface water infrastructure from the Proposed Scheme in the permanent case.

9.1.4 Any ground settlement arising from the proposed tunnels is unlikely to increase the risk of flooding from the Grand Union Canal (Paddington Branch).

9.1.5 There will be no significant increase in the risk of flooding to third party receptors arising from the Proposed Scheme.

9.2 Residual flood risks to Proposed Scheme

9.2.1 Residual flood risks arise in situations that are not included in standard design scenarios, for example when a culvert becomes blocked causing flooding upstream. All design is generally undertaken assuming that existing infrastructure is functioning under normal conditions. Consequently, there may be areas where the potential severity of flooding may exceed the design standard under certain circumstances.

9.2.2 The Proposed Scheme will be in tunnel throughout CFA5. There will be no residual risk of flooding to the below ground components of the scheme, however, there are potential residual risks to the two above ground vent shafts.

9.2.3 Blockage of underground surface water collections systems can cause surcharge and associated flooding. All vent shafts lie on raised land relative to surrounding ground or away from overland flow pathways and in general, any additional flooding arising from blocked sewers would be expected to flow away from the sites. There will be no significant residual risk of flood waters ponding at either of the vent shafts as a result of blocked sewers in the area.

9.3 Residual effects of the Proposed Scheme on flood risk

9.3.1 The Proposed Scheme will not create an additional risk of blockage of sewer systems and will not lie within any area of significant risk of flooding. Surface and foul water discharges from the vent shafts will be attenuated to avoid increasing the load on existing water collection systems and will therefore not increase the potential effect of any residual flooding arising from blocked sewers. There will therefore be no significant impact arising from the Proposed Scheme on the residual risk of flooding to third parties.

9.4 Compliance with local planning policy

9.4.1 The Proposed Scheme includes an allowance for future increases in the risk of flooding as a result of climate change by adding a 20% increase to river flows and a 30% increase to rainfall intensities and flows in minor watercourses as recommended in the NPPF Technical Guidance document. Attenuation will be provided to ensure that the rate of runoff from permanent infrastructure, such as at the Westgate, Greenpark Way and Mandeville Road vent shafts, will not increase as a result of the Proposed Scheme. This will ensure that there will be no increase in the risk of surface water flooding, especially in areas where a risk currently exists. The Proposed Scheme will be in tunnel at the crossing of the River Brent, minimising any impact on the river corridor, as identified in the LBE SFRA.

9.4.2 The Proposed Scheme will be in compliance with the recommendations of the local authority SFRA reports, core strategies and other local planning documents.

10 References

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